

IV.—Notes on Collecting Ferns, with particular Reference to certain Bornean Ferns of Considerable Interest. By D. H. CAMPBELL, Professor of Botany, Stanford University, California.

No group of plants is more interesting to the botanist than the ferns which are, in a sense, connecting links between the seed-bearing plants and the lower mosses or liverworts.

Every collector of ferns knows that the classification is based mainly upon the position of the little capsules, or sporangia, which contain the spores. The latter are deposited as a fine powder, as will be seen if a leaf with ripe sporangia be laid upon a sheet of paper. If these spores are examined microscopically each is seen to be a single cell, whose outer membranes are more or less thickened to protect the contents against injury. Many persons who collect ferns are quite unaware that the plants developed from these spores are very different indeed from the fern as it is usually known.

If the spores are sown upon moist earth, or a bit of tile, in the course of a few weeks a crop of little plants will appear, which show no trace of the familiar fern leaf, but are thin, green, filmy structures, lying flat on the ground, and usually somewhat heart-shaped in outline. In most ferns these simple little plants—"prothallia" or "prothalli," to use their technical name—are not more than a quarter of an inch or less in diameter. In certain forms, however, the prothallia may be much larger.

The prothallia of many ferns may be easily found by examining moist banks, &c., where ferns are growing. When one wishes to collect prothallia of a given species it is best, if possible, to select a bank where the fern is growing in such a position as to allow the spores to fall in small crevices, or upon freshly exposed soil, where mosses, &c., have not had time to take possession. In a climate like that of Sarawak, almost any bank or recent cutting, where the earth has been freshly exposed, will almost invariably show a rich crop of fern prothallia.

Owing to the great similarity in the appearance of the prothallia of most common ferns, it is often difficult to tell to what species they belong. It is best to first select specimens with the little ferns attached to them, so that one can tell the species, and then examine others of the same group for the earlier stages.

For future study the prothallia may be preserved in ordinary alcohol, or alcohol to which 10 per cent. of strong acetic acid has been added.

Of course, the surest way to get the prothallia of a given species of fern is to grow them from the spores, and this plan may be recommended to those who are willing to take a little trouble. The fresh spores may be sown either upon fine earth, rotten wood, or bits of tile. These must be kept moist, but not as a rule soaking wet. It is advisable to sterilize the earth by heating. The bits of tile or rotten wood may be plunged into boiling water for an hour or so before the spores are sown. This checks the development of mosses and algæ, which otherwise are apt to choke out the young ferns. It is also advisable to remove from time to time such alien growths as may appear, in spite of the sterilizing of the soil.

A microscopic study of the prothallium shows that it bears reproductive organs within which are produced sexual cells—actively swimming sperms or male cells—and non-motile eggs, female cells, both sperms and eggs much resembling the corresponding reproductive cells of an animal. As in the latter there is a fusion of the two sex cells, the fertilized egg then developing into the future fern. This embryo plant soon shows the characteristic leaf, and a root is formed which grows downward into the earth. The young fern, however, retains its connection with the prothallium for some time, but ultimately the prothallium dies, leaving the little fern or “sporophyte” rooted in the ground.

The sporophyte, or fern as we usually know it, is a strictly non-sexual organism, as the reproductive cells or spores are produced by simple cell division, and there is nothing in the nature of fertilization preliminary to their germination.

It is thus evident that in the fern there is an alternate development of sexual plants (*prothallia*) derived from the germination of the spores, and of non-sexual plants (*sporophytes*) arising from the fertilized egg.

There is every reason to believe that the sexual plant or

prothallium is the older phase, and represents the ancestral plant from which later the non-sexual sporophyte was developed. A careful study of the prothallium is therefore of the greatest importance in determining the relationships of the different groups of ferns among themselves and to other plants.

In Borneo, as in all other countries, the great majority of the ferns belong to a single family, the Polypodiaceæ, whose prothallia have been very completely studied, and whose life-history is well known.

There are, however, a number of other ferns whose prothallia are much less known, and material of which might be of real scientific value. Of the Bornean ferns whose prothallia are quite unknown may be mentioned the two species of *Matonia*—*M. pectinata*, and *M. sarmentosa*.

The genus *Matonia* comprises but two species: *M. pectinata* is a handsome fern with large fan-shaped fronds borne on long stalks, sometimes 6 ft. or more in height. It was originally found on Mount Ophir in Malacca, but has since been collected in several other localities. In Sarawak it is known from near the summits of Matang and Santubong.

M. sarmentosa is known only from Sarawak, where it is found in the limestone caves of Niah, Bidi and Bau. Its slender pendent fronds are very unlike those of *M. pectinata*.

These two ferns are the only living representatives of the family Matoniaceæ, of which there are a number of fossil species, especially from the early secondary formations. It is very desirable that the prothallia should be found, as they would probably help to determine the relationship of the Matoniaceæ to other living ferns.

The peculiar genus *Schizæa*, one of which the writer found with prothallia on Mount Matang, also is incompletely known. *Schizæa malaccana* is a small fern with slender grass-like sterile leaves, the fertile ones being similar, but tipped by a cluster of small spore-bearing leaflets. This plant was abundant near the top of Matang, growing on steep, wet banks. The form of the peculiar alga-like prothallium is due probably to its almost aquatic habit. The prothallium of the related genus *Lygodium* (the common climbing ferns) is much like that of the ordinary ferns.

One of the most important families of ferns is that of the Marattiaceæ, represented in Sarawak by four genera,

none of which, however, can be said to be common. They occur only in small numbers, and usually in the deep jungle. The four Bornean genera are *Angiopteris*, *Marattia*, *Macroglossum* and *Kaulfussia*. Of these *Macroglossum* is, so far as is known, peculiar to Sarawak. In all of these the prothallium is often of relatively great size.

The Marattiaceæ are specially interesting to the botanist, because they are more nearly related to the majority of the older fossil ferns than are any other existing ferns. Most of the abundant ferns and fern-like plants occurring as fossils in the coal measures, for example, are either true Marattiaceæ, or are closely related to them.

The primitive nature of the living Marattiaceæ is shown by the prothallium, which attains much greater dimensions than that of any of the common ferns, and may live for several years. The writer recently, in Sumatra, found prothallia of a species of *Angiopteris* more than an inch across, and very thick and fleshy, so that it was hard to believe that they were fern-prothallia and not large liverworts.

The prothallium is always more massive than in the ordinary ferns, and the reproductive organs quite different. Where very young plants (sporophytes) are attached to the prothallium, they can at once be distinguished from the common ferns by their position. In the Marattiaceæ the young fern always grows through the prothallium, the first leaf emerging from the upper surface of the prothallium. In the ordinary ferns the first leaf emerges on the lower surface, and bends upward in front of the prothallium apex.

The most interesting of the Bornean Marattiaceæ is a fine fern to which Professor E. B. Copeland gave the name *Macroglossum alidæ*. This is a very handsome fern with leaves sometimes upwards of 12 ft. in length. It was found first at Bau by Mr. Young, and later by Mr. Moulton at Penrissen. The writer saw a single specimen at the base of Mount Matang, and also visited the station at Bau, where the plant was growing luxuriantly, and where a number of young plants and prothallia were secured. The latter are much like those of *Angiopteris*, with which *Macroglossum* is undoubtedly related.

Since leaving Borneo the writer made a brief visit to the famous botanical gardens at Buitenzorg in Java, and to his astonishment found there a fine plant of a fern apparently identical with the Sarawak species. This

plant, it seems, had been examined by a well-known botanist, Raciborski, who, about ten years ago, called it *Angiopteris Smithii*. There is no record of where the plant came from, but it has been in the gardens for many years.

As collections of plants are frequently sent from Borneo to Buitenzorg, it is extremely likely that the plant in question was sent from some part of Borneo; but whether from Sarawak or, what is more likely, from Dutch Borneo, can never be ascertained; so for the present, at least, the only known native localities for the plant are in Sarawak.*

Another peculiar family is that of the Ophioglossaceæ—adder-tongue ferns. They are not common in Sarawak, and the prothallium is especially difficult to find, as it is subterranean and quite destitute of the green colour of other fern prothallia.

The Ophioglossaceæ can be recognized at once by the characteristic fertile leaves. The sporangia are borne upon a sort of spike having usually a long stalk inserted at the base of the leaf-blade. The latter, in the genus *Ophioglossum*, is quite undivided, and not at all fern-like in appearance. In *Helminthostachys* the leaf-blade is palmately divided, and is in some respects not unlike the leaves of the Marattiaceæ.

There is much reason for assuming that the Ophioglossaceæ and Marattiaceæ are really related, and that the Ophioglossaceæ are also very old types. There is, however, very little fossil evidence—due perhaps to the fact that the Ophioglossaceæ are soft fleshy plants, not fitted to leave well-preserved fossil remains.

Most species of *Ophioglossum* are small terrestrial plants, sometimes only a couple of inches high, and seldom more than 6 to 8 inches. One species, however, *O. pendulum*, is an epiphyte, and its long pendent fronds, sometimes forked, may be 4 or 5 ft. in length.

* [In a letter dated October 9th, 1913, Professor Campbell writes: "I am just now making a careful investigation of *Macroglossum*, and I find that the Sarawak form, while much resembling Raciborski's *Angiopteris Smithii*, is quite distinct. The material of the Buitenzorg plant I showed Copeland was not mature, but when I came to examine it more carefully on my return here, I found so many differences that I am convinced that the two forms are specifically distinct. Apart from the fact that the sori of the Sarawak species contain more than twice as many sporangia, there are differences in the structure of the sporangia and the indusium, as well as more marked differences in the anatomy of the leaf—so I think it is safe to say that Copeland's name will hold for your plant, while the other now becomes *Macroglossum Smithii*."]—ED.

Helminthostachys has but a single species. It is usually found in rich humus soil in the lower forest. It is a foot or so in height.

Both genera, *Ophioglossum* and *Helminthostachys*, are reported from Sarawak, but they are evidently rare, and the chances of finding their prothallia are small.